Spring 2009
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Energy Industry

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ENERGY 2009

ABSTRACT: Energy is the foundation of America's economic well being, national security, and quality of life. Much of America's national power is built on a foundation of inexpensive, readily available, and reliable energy. Unfortunately, the current energy challenges facing the U.S. are very complex and there is no silver bullet. As much as the U.S. needs to focus on its own energy needs, it must also have global energy awareness, a real concern about the energy requirements of other nations, and demonstrate a consistent "do as we do" leadership role. To achieve this, America needs a responsible energy agency that understands the national energy portfolio, can address the most profound U.S. challenges to include the continued reliance of foreign oil in the transportation sector, aging/inefficient electricity generation/transmission infrastructure, increasing energy consumption, and growing environmental concerns, and, most importantly, take specific actions to fulfill a long term vision for energy. The cornerstone for this long term vision is a national energy strategy that includes designation of a clear, responsible commission for leading long term national energy security planning/implementation, diversification of America's energy portfolio, assumption of a global leadership role in the energy area, prioritizing/incentivizing innovations, and reducing energy consumption.

When determined, the U.S. can literally "fly to the moon." As the U.S. has done with the space program or other national challenges, it is time to take this same dedication into our national energy and related environmental realms. Energy is the foundation of America's economic well being, national security, and quality of life. Much of America's national power is built on a foundation of inexpensive, readily available, and reliable energy. Any U.S. failure to adequately address global challenges will weaken American political influence, military power, and economic strength.

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PLACES VISITED

Domestic

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Chevron North America, TX
Conowingo Hydroelectric Station, MD
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Covanta Montgomery, Inc., MD
Defense Energy Support Center, VA
Division of Solid Waste Service, Montgomery County, MD
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Shell Deer Park Refinery, TX
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Three Mile Island Generating Station, PA

International

Australian Energy Regulator, Melbourne, Australia
Australian Nuclear and Scientific Technology Organisation, Australia
Centre for Energy and Environmental Markets, University of New South Wales, Sydney, Australia
Ceramic Fuel Cell Ltd, Victoria, Australia
Cooperative Research Center for Greenhouse Gas Technologies, Canberra, Australia
Institute of Earth Science and Engineering, University of Auckland, New Zealand
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"Our enemies are fully aware that they can use oil as a weapon against America. And if we don't take this threat as seriously as the bombs they build or the guns they buy, we will be fighting the War on Terror for a long, long time." – President-Elect Barack Obama

INTRODUCTION

Energy is the foundation of America's economic well being, national security, and quality of life. As much as any military campaign, the U.S. must plan extensively on the national way ahead for energy. The current energy challenges facing the U.S. are very complex and there is no silver bullet. As much as the U.S. needs to focus on its energy needs, it must also have global energy awareness, a real concern about the energy requirements of other nations, and demonstrate a consistent "do as we do" leadership role. Energy is a global issue, not simply a domestic one. A U.S. failure to adequately address global challenges will weaken American political influence, military power, and economic strength.

Much of America's national power is built on a foundation of inexpensive, readily available, and reliable energy. This relationship was clearly demonstrated during the gasoline shortages of the 1970s. However, the crisis resolved itself and oil and gas prices were one again lowered. Subsequently, American interest in energy security waned and few significant measures were taken. Then, in the summer of 2008, when the price of gas in the U.S. reached $4.11 per gallon, energy issues once again rose to the forefront of national attention and reinvigorated the American national security energy dialogue. Mastering the energy sector is essential to national security. Energy is the cornerstone of America's economic power and this economic power is the foundation of our political and military strength. Energy security *is* national security.

The U.S. must develop a cogent, comprehensive national energy strategy within a global context or face problems in the future. Such problems include energy shortages, volatile prices, aging infrastructure, growing environmental risks and national security challenges. As a foundation for the proposed energy strategy, the U.S. must develop a comprehensive perspective that addresses not only the future security of different types of energy, but considers these energy types and diversity through availability, price, and environmental lenses. To develop this way ahead, the U.S. needs to 1) understand its energy portfolio—including the state of the various U.S. sources of energy; 2) define and address the most profound U.S. challenges to include the continued reliance of foreign oil in the transportation sector, aging/inefficient electricity generation/transmission infrastructure, increasing energy consumption, and growing environmental concerns, and 3) take specific actions within a coordinated national energy strategy.

Energy security is a function of availability and affordability, both of which depend on many interrelated factors. Affordable, available energy continues to be the foundation for the nation's economic growth. The explosive economic growth in Asia is driving worldwide energy demand to unprecedented levels and spurring intense global competition for finite fossil fuel resources. Along with this economic development, is a growing concern of environmental impact. Although it is very difficult to predict future energy markets, the International Energy Agency expects global demand for energy to increase by 45 percent between 2008 and 2030.[3] This rapidly increasing worldwide demand in a relatively short period of time logically leads to higher energy prices and international tension over resources unless supply keeps pace with the growing demand. The U.S. requirements contribute to this tension as U.S. dependence on foreign oil has increased to 58%. The U.S. must act now to develop and implement a *long term* national energy strategy. America's future energy security is best assured through a strategy of establishing national energy

leadership, increasing and diversifying America's energy sources while reducing consumption, making innovation a priority, and taking a proactive leadership role in the global energy market.

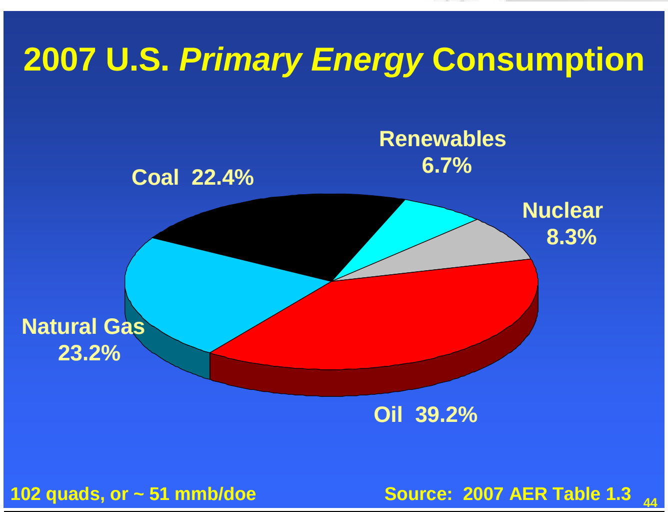
I. US ENERGY PORTFOLIO: PROVIDING POWER TO "THE PEOPLE"

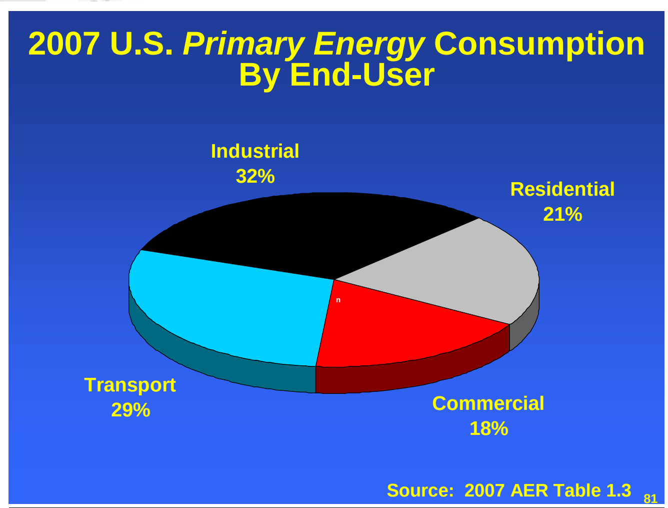
Industry Defined

The ***energy industry***[1] is a generic term for all of the industries involved in the production and sale of energy, including fuel extraction, manufacturing, refining and distribution. American society consumes large amounts of fuel, and the energy industry is a crucial part element in almost all countries. In particular, the energy industry includes the:

- Petroleum industry, to include oil companies, petroleum refineries, fuel transport, and sales
- Natural gas industry to include extraction, coal gas manufacture, distribution, and sales
- Electrical power industry to include electricity generation, electric power distribution, and sales
- Coal industry
- Nuclear power industry
- Renewable and alternative energy industry to include hydroelectric power, wind power, and solar power generation, hydrogen, and the manufacture, distribution and sale of alternative fuels such as ethanol.

Summary of Energy Sources, Consumption, and Analysis





As illustrated in the graphs above, U.S. energy consumption is fueled by oil, natural gas, and coal with oil being the principal source of energy. Industrial and transportation sectors are the largest users of energy with residential and commercial users close behind. These facts highlight the key challenges to be addressed in a proposed long-term energy strategy.

The development of an effective and comprehensive energy strategy is based upon a thorough understanding of each of the major energy sources. To communicate a common understanding of the energy sources (fossil, nuclear, renewables), a short review of each energy

source along with the percentage of the total U.S. consumption and analysis is provided. An examination and balancing of the critical "trinity" of energy issues—availability, price, and environment is also provided for each energy source.

"***Energy availability***" is the ability to obtain, move, refine, distribute, and secure energy. The U.S. must have the ability to access and gather raw energy materials, move them to facilities where it can be processed, and then distribute the output to users. One type of infrastructure is required for production and another for distributing the final product to users. Integral to availability is security of the energy elements. Security involves both 1) physically protecting energy sources/infrastructure and 2) reliability of permissions and access. Physical protection is the ability to protect the energy elements from attack or natural disaster. Reliability is assurance by companies and/or nations to continue to provide it.

"***Energy price***" refers to the price to produce/use energy and typically drives the energy providers' ability to stay economically profitable. The free market (supply & demand) is normally the primary and best tool for regulating energy use. Today's energy market has become more of a global and less of a national market. The demand for energy outside the U.S. is growing quickly and international demand has a significant impact on U.S. prices. Through policy and incentives, government can influence required change and soften anticipated market difficulties. However, government efforts should normally be deliberate, specific, and limited. Too much or too broad a government influence can result in artificial economic forces that destabilize the market and result in even greater long term problems.

"***Environmental***" considerations include both traditional localized pollution concerns (air, water, toxic waste, etc.) and greater global pollution (carbon, climate change, ozone, etc.). While environmental concerns have not weighed as heavily in the past, they are quickly becoming more predominant than previously when compared to the "availability" and "price" elements of the trinity. In the U.S., oil rich areas have been restricted from drilling because of environmental concerns. As the world's greatest energy consumer, the U.S. must be concerned with the local and global environment or risk global enmity if it fails to be progressive in addressing global challenges.

Carbon Fossil Fuels—The Current U.S. Energy Staple

Petroleum—Oil moves our nation! Petroleum accounts for 40% of U.S. energy consumption[2] and provides 95% of the energy required in the transportation sector[3] with transportation accounting for 70% of all U.S. oil consumption.

Availability: The U.S. reached peak oil production in 1971, and since that time it has been in steady decline.[4] However, the US now imports 58% of its oil needs and these imports comprised 56% of the overall trade deficit.[5] Consuming almost one-quarter of the world's oil supply (over 20 million barrels per day (mbd) in 2008),[6] the U.S. imports over 10 mbd per year. This results in the US being vulnerable to "oil shocks" and to sudden increases in oil prices. The Energy Information Administration (EIA) estimates that U.S. demand will increase 11% from 2007 to 2030.[7]

There is a bright side, however. The EIA predicts that U.S. domestic oil production will, after more than 20 years of declining production, increase significantly in the future. This is primarily due to increased production in the Gulf of Mexico, the Pacific, and onshore enhanced oil recovery projects.[8] During this seminar's Apr 09 visit to Houston, Halliburton described new deep water oil drilling technologies which allows oil companies to exploit reserves that would otherwise

be untapped. For instance, in late 2008, British Petroleum's Thunderhorse Oil Platform started producing oil in the Gulf of Mexico, at a rate of 300,000 barrels per day. Chevron's Tahiti platform is expected to produce 125,000 barrels per day by the summer of 2009. Both of these platforms add significant amounts to the approximate five million barrels per day the U.S. is already producing. The overall effect of a relatively small increase in demand (11% through 2030) and future increases in production will be a net decrease in U.S. oil imports. Through 2030, U.S. oil imports, while still large, are projected to drop from 60% to 41% of total U.S. oil consumption.[9] This high level of reliance on imported oil is a national security issue and reductions in U.S. dependence are important. It should be noted that these production estimates assume approval of new drilling in the Alaska National Wildlife Refuge, which is anticipated to produce 780,000 barrels per day at its peak production.[10]

Price: Oil has been subject to significant price fluctuations in the recent past, which has impacted the U.S. economy. Moreover, world oil consumption has climbed from 67 mbd in 1992 to 83 mbd in 2005[11], and this growing demand is leading to rising prices. The rise in oil prices affects the global economy as a whole. The U.S. imports over $2 trillion dollars worth of goods/services annually,[12] and increases in energy prices globally affect the price of U.S. imported goods/services. In addition, there are choke points to this global oil production and transportation network. Twenty percent of the world's oil flows through the Strait of Hormuz. This creates a security concern with respect to supply, and ensuring access is a significant externality that adds to the true cost of oil. One example of an externality is the cost of military forces required to ensure the free flow of traffic through the Persian Gulf. In 2008 alone, the price of gasoline spiked to the unprecedented level of $4.11 per gallon[13] when a barrel of oil was selling for $147, three times higher than any previous price spike.

Environment: Refining and burning of petroleum products is a significant pollutant and a major cause of greenhouse gas emissions. In particular, petroleum accounted for approximately 44% of carbon dioxide emissions in the U.S. in 2006.[14] No affordable technology that would reduce greenhouse gas emissions from this source of energy appears available in the near term.

Natural Gas—Clean and Clear! The U.S. consumes approximately 22 trillion cubic feet (TCf) of natural gas per year.[15] This accounts for roughly 22% of all U.S. energy consumption.[16] By percentage, natural gas is used by industry (30%), for power generation (30%), for homes (22%), for commercial applications (14%) and to a much lesser degree for transportation (3%).[17]

Availability: As in the case of oil, natural gas is a finite resource. However, unlike oil, the U.S. imports only 16% of its natural gas needs making it a more secure energy source. According to EIA projections, as natural gas production in the Atlantic, Pacific, Gulf of Mexico, and Alaska increase, net imports of natural gas are expected to drop from an already low 16% to an even lower 3% of total U.S. natural gas consumption.[18] Currently, the U.S. has 167 TCf of proven reserves and an estimated 1023 TCf of "unproven" reserves or ~50 yrs of supply based on current rates of consumption.[19]

Price: Natural gas is an affordable method to generate power. Typically, while the overnight construction costs for a gas fired plant are low, the marginal cost of generating power is high. For instance, in 2005, overnight construction cost for gas fired plants ranged from $400-800 per kW, low compared to coal fired and nuclear power plants.[20] In 2007, the marginal cost to generate electricity from gas (including both Operation and Maintenance and fuel costs) was 6.8 cents per kWh.[21]

Environment: Gas fired power generation plants release approximately 620 tons of CO2 per GWh of electricity produced.[22] This is approximately 40% less than the amount of carbon released by coal fired plants and as a result, has been an attractive alternative to coal.

Coal—King of U.S. Fossil Resources! Coal accounts for roughly 23% of all U.S. energy consumption.[23] Coal is used primarily in generating electricity and provides ~50% of the U.S. electrical power generation. [24] Coal will be a major part of America's portfolio of energy sources for many years to come.

Availability: Coal is incredibly abundant domestically and as such, access to coal is secure. In fact, the U.S. has enough domestic reserves (nearly 242 billion tons) to last for 223 years at current use rates.[25] As observed during this seminar's visit to the Consol coal mine in West Virginia, long wall mining technology has exponentially improved the efficiency of underground coal mining. Coal can also be converted to oil should oil become too expensive or if the US is at some point unable to import its oil needs.

Price: Currently coal is the most affordable method to generate power. While the overnight construction costs for a coal plant are moderate; the marginal cost of generating power is low. For instance, the construction cost for a coal fired plant is $1000-1500/KWe or approximately two times the upfront costs of a gas fired plant.[26] The marginal cost for generating power from coal is 2.5 cents per kWh.[27]

Environment: The greatest challenge to using coal as a power source is coal's negative environmental impact. The burning of coal emits sulfur dioxide and nitrogen oxide, two primary causes of acid rain. While affordable technology has been developed to better cope with these discharges, coal accounts for 41% of all fossil fuel CO2 emissions, the primary source of "greenhouse gas"[28] and unfortunately affordable technology is not available to capture it. Coal fired plants produce about 1000 tons of CO2 per GWh—significantly more than any other form of power generation.[29] Until affordable carbon capture technology is adequately developed, coal will be environmentally unfriendly.

<u>**Nuclear Power**</u>

Nuclear—Dependable and Carbon-Free! Nuclear power accounts for roughly 8.3% of all U.S. energy consumption. Nuclear power is used primarily in generating electricity and provides ~19% of U.S. electrical power. Nuclear energy ranks third among America's energy generation methods.

Availability: The US currently has 104 nuclear reactors in operation and is the world's largest producer of nuclear power. During 2007, these reactors generated 806.5 billion kW/h of electricity, a new US record. However, the amount of nuclear power generated as a percent of total power generation is waning because electricity demand is rising and new nuclear plants are not being built to accommodate this increase. The last nuclear power plant to be built came on line in 1996. Since then, no new nuclear plants have been constructed primarily due to a combination of extensive regulations, political issues, and "Not in My Back Yard (NIMBY)" sensitivities. New reactor plant investment and construction was made more attractive by the Energy Policy Act of 2005. Incentives include production tax credits, federal risk insurance to cover regulatory delays, and federal loan guarantees for advanced nuclear reactors for up to 80% of the project cost.[30] This

government stimulus has resulted in new reactor proposals with construction expected to start in 2010 with electrical production available in 2014.[31]

Price: The production price of electricity from nuclear power is approximately 1.6 to 2.6 cents per kWh. By comparison, the production costs of electricity from oil and gas varied widely from a low of 3.60 to a high of 10.26 cents per kWh.[32] However, these costs do not reflect the large investment of time and capital to build and license a nuclear power plant. To compete in a deregulated industry, the production costs for nuclear must be below 2.0 cents per kWh.[33] Uranium accounts for only 5-13 percent of the operating costs for nuclear power plants. Therefore, nuclear power generation costs are not as sensitive to the fluctuating fuel costs[34] as electrical power generated by gas and coal-fired electric plants where fuels prices are a major production cost. However, nuclear power plants are challenged by enormous initial capital costs and a lengthy permitting process. On average, it costs about $6-8 billion and takes 10-12 years to build a plant.[35] In the future, rising energy costs (most notably those associated with transitioning to clean energy from fossil fuels) coupled with more efficient timelines for nuclear plant licensing and construction, may lower the investment risk for new reactors.

Environmental: Since nuclear reactors do not emit CO2 or other harmful pollutants into the atmosphere, nuclear power is not viewed as a contributor to global warming. However, there are other environmental issues that are as important. Among these issues are the risk of radiation leaks, safe disposal of radioactive waste material, and the continuous demand for large quantities of water to cool the reactors. Given the politically charged nature of nuclear power, partially due to the accidents at Three Mile Island and Chernobyl, nuclear power development has not been as attractive as other sources of power generation. It is important to note that during a visit to Three Mile Island, we learned there was no significant release of radiation during the admittedly serious partial meltdown and the nuclear industry's mishap rate is near zero. The life-threatening radioactive material was fully contained due to the rigorous safety standards and robust containment infrastructure.

In terms of nuclear waste disposal, during the seminar's visit to Australia's Nuclear and Scientific Technology Organisation, experts described how a process they refer to as "synroc" can be used to process radioactive waste into a safe, stable, environmentally friendly storage container. Nuclear experts in the U.S. and Australia point to the increasing public acceptability of nuclear power generation. However, today, much of the environmental community remains divided on nuclear power—those who are concerned with global warming often favor it while those concerned with radiation containment and disposal oppose it.

Renewables

Bio-fuels—Planting Energy! Bio-fuels (ethanol, in particular) have been increasingly used in the transportation sector.[36] Ethanol can be made from corn or sugarcane. Ethanol burns cleaner than oil and is considered more environmentally friendly to the atmosphere. It is also available domestically, reducing the need for imported oil and improving energy security. It has roughly two-thirds the energy of an equal amount of petroleum-based fuel. Bio-fuel can also be generated from switchgrass, which can be grown on land less suitable for food crops such as corn. However, there are high capital costs associated with these types of plants.[37] Recently, there have been developments on a new kind of bio-fuel. Algae are particularly efficient as a source of biomass. They convert sunlight, water and carbon dioxide to algal biomass, and are exceedingly rich in oil which can be converted to biodiesel.[38] Compared to other crops, they can produce up to 50 times

the amount of fuel on the same amount of land, potentially yielding 100,000 gallons of fuel per acre each year.[39] The production of biodiesel uses less fuel than the production of ethanol and it contains more energy per gallon. Recent tests performed by the U.S. Air Force and Continental Airlines demonstrate the viability of algae-based bio-fuels.[40] Experts indicate this type of fuel has better energy content and other properties that make it superior. It does not freeze at high altitudes, and it is lighter.

Availability: Ethanol is currently produced domestically by growing corn, which is fermented. However, there is not enough land to grow the corn necessary to replace U.S. dependence on imported oil. The same is true for switchgrass. In addition, mass production methods of bio-fuel made from algae are still under development. There are technical hurdles to overcome before this type of fuel can be produced on the scale necessary to impact the dependence on foreign oil. The bottom line is that bio-fuels can reduce U.S. need for oil, but not replace it.

Price: Bio-fuel from ethanol is cost effective for the producers due to federal and state subsidies.[41] Without these subsidies and other governmental mandates for its use, ethanol is not economically viable today.

Environment: Although ethanol burns cleaner than petroleum base products, as more land is dedicated to growing corn for ethanol, less land is available for growing food. Ethanol production has been blamed for the increase in world food prices and the subsequent impact on food importing nations. In addition, creating ethanol from corn may actually increase carbon dioxide emissions due to the plowing of fields, planting of corn, manufacturing and spreading fertilizer, then harvesting and refining.[42] It is estimated that energy needed to produce ethanol from corn is equivalent to two-thirds of a gallon of oil for every one gallon of equivalent ethanol from corn.[43] Growing switchgrass or algae (as opposed to corn) to make bio-fuel still absorbs carbon dioxide, without the negative impact on food imports/exports.[1]

Wind—A Breath of Clean Energy! Wind power has the greatest near-term growth potential of all renewable energy sources.[44] In fact, wind power capacity has increased in the U.S. from 1,000 MW in 1985 to 6,740 MW in 2005,[45] to 25,170 MW in 2008.[46] From 2005 to 2008, U.S. wind power capacity increased by nearly 400% and provides enough power for 5.7 million homes. In spite of these mammoth increases, wind accounts for just 1.5% of America’s power, but it now makes up 12% of the renewable energy portfolio.[47] However, wind power faces challenges such as instability of electricity production due to varying and unreliable wind velocity, sight pollution, inefficient electricity generation, transmission challenges, and high capital costs.[48]

Availability: The U.S. has excellent wind resources throughout many parts of the country, but wind is not a continuously reliable source of power. Therefore, it is best suited to supplement an existing power grid, rather than be the primary source of power. Nevertheless, the Department of Energy’s stated goal is for wind to provide 20% of U.S. electricity by 2030. Not only is this realistic, but given the current rates of wind power expansion, this goal may actually be surpassed. Wind turbines are rapidly improving, and are already exponentially more efficient than they were

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[1] Although E85 and normal gasoline generate similar levels of carbon emissions from vehicles, the advantage of switch grass-ethanol over corn-based ethanol is derived from the energy saved by not having to replant it every year. Additionally, switch grass offers 11,550 gallons of ethanol per acre versus 440 for same acre of corn.
(source: https://php.radford.edu/~wkovarik/drupal/?q=node/46)

just ten years ago. On a visit to Texas, it was recognized the transmission issue must be better addressed and the U.S. might use that state's wind efforts as a model. There, wind power has expanded at a greater rate than anywhere else in the country with plans in place to build the transmission infrastructure so that West Texas wind energy can power East Texas. In spite of its intermittent nature (which limits its value as a base load power source), wind will play a vital role in the U.S. future energy portfolio.

Price: The cost of a wind turbine is approximately $700 per kW, or about 2.7 cents per kWh.[49] The cost of installation, land use planning/permitting and lease or purchase, add up to approximately $270 per kW, adding 1 cent per kWh. The operating costs, including maintenance, land rent and insurance, add an additional 1 cent per kWh. Therefore, the total cost of wind energy is approximately 4.7 cents per kWh, making it competitive with fossil fuels.[50]

Environment: Wind has a zero carbon footprint, but large swaths of land are needed for wind farms to generate enough power to become viable for commercial energy production. Much of the land needed for large wind generation plants is typically found in remote areas and the transmission lines needed to bring the power to the consumers faces huge challenges from environmentalists concerned with the impact on the land and habitats. This is complicated further by the NIMBY position of special interest groups claiming degradation of lands or "view pollution" caused by turbines in their line of sight.

Solar—Lighting the Way! Solar accounts for <1% of all U.S. energy consumption.

Availability: In the U.S. alone, the total capacity of electricity produced by solar generation, which includes photovoltaic (PV) and solar concentration power (CSP) generation methods, increased by 17% in 2008 and now stands at 8,775 MW[51]. However, despite this tremendous growth, solar energy still only accounts for approximately 0.8% of the total U.S. electricity generation capacity.[52] Across America, PV systems connected to the grid reached 792 MW in 2008, growing 58% from the previous year. However, this pales in comparison to Spain and Germany, which added 2,460 MW and 1,860 MW of PV solar power, respectively, in 2008.[53] Worldwide PV electricity generation is projected to increase from just a few TWh in 2006 to 42 TWh in 2015, and 245 TWh in 2030.[54] Most of this increase comes from individual buildings placing solar panels on rooftops versus traditional mass generation plants like coal or nuclear.

Price: This technology has been in use since the early 1980's and significant improvements in efficiencies have lead to decreasing costs. Despite these improvements, solar remains expensive relative to other forms of power. "In order for the solar industry to make a systematic penetration in to the electricity segment, installed solar system costs will need to drop from … the present 30 cents per kWh to around 10 cents per kWh, which would allow it to compete more strongly with other renewables and capture a significant share of the electricity market."[55] The other major form of solar power, CSP can cost anywhere from 15 to 25 cents per kWh. While the low end of this range is competitive with current gas prices, the EIA predicts that the cost will come down to 10 cents per kWh by 2030.[56] They project that CSP generation will reach 11 TWh by 2015 and 107 TWh by 2030.[57]

Environmental: Since solar PV systems can be used for direct applications ranging from small light power sources to full scale residential or industrial applications in remote areas where grid connectivity is not an option, they provide a viable environmentally friendly solution to remote power generation. However, large scale PV or CSP sites require large swaths of land in order to generate enough power to become viable as a commercial source of energy production. A good example is the large CSP facility being built in the desert near Las Vegas. Since the land

needed for large solar generation plants is typically found in remote areas, the transmission lines needed to bring the power to the consumers faces significant challenges from environmentalists concerned with the impact on the land and habitats near the plant and transmission lines. This is complicated further by the NIMBY position of special interest groups claiming degradation of lands or "view pollution." This debate frequently overshadows the positive environmental benefit derived from solar power generation being a "zero carbon emitter."

Hydroelectricity—Running Water for Running the Nation! Hydroelectric power is used primarily in generating electricity and provides 10-12% of the U.S. electrical power generation. Hydroelectricity accounts for 71% of all renewable electricity generation in the U.S.[58]

Availability: With over 2,400 facilities, the US is the second largest producer of hydropower worldwide, behind Canada.[59] Modern hydro turbines can convert as much as 90% of the available energy into electricity. The best fossil fuel plants are only about 50% efficient. Efficiency could be even further increased by refurbishing hydroelectric equipment. An improvement of only 1% would supply electricity to an additional 300,000 households.[60] Hydroelectric power is dependent upon adequate rainfall. Additionally, unlike concerns related to reaching "peak oil" where new "proven oil reserves continue to push the peak further into the future, recent trends show the U.S. may actually be reaching "peak hydro." Hydro power generation as a share of the total electricity generation capacity in the U.S. continues to decline. This decline is exacerbated by the increased demand for water from the reservoirs behind the dams and environmental factors such as drought like conditions in large areas upstream from dams across the U.S.

A new area that may expand the use of water is tidal technologies.[61] These technologies capture the power of incoming and outgoing tides to power turbines to produce electricity, but these projects are still in their infancy.

Price: The cost of hydroelectricity is ~0.85cents per kWh. Upfront capital cost for a new hydroelectric facility is approximately $4.6 billion.[62] So once the facility is built, the electricity is inexpensive.

Environmental: Hydroelectric power does not generate common green house gases. While the U.S. has the potential for up to 30,000 MW of additional hydro power generation, other environmental concerns have significantly limited new development. Only 600 MW of new hydro power are planned in the U.S.[63] One major issue raised by environmental groups is the impact on fish species.[64] Other environmental concerns include the availability of water for irrigation, the free flow of rivers for wildlife, and river-based commerce. These issues continue to restrict growth of U.S. hydroelectric power generation capabilities.

Geothermal—Natural Heat for Natural Energy! This form of energy represents less than 1% of electricity production in the U.S. The current production of geothermal energy worldwide places it third among renewables, following hydroelectricity and biomass, and ahead of solar and wind. As of August 2008, geothermal electric power generation is occurring in seven U.S. states with capacity rated at 2957.94 MW.[65]

Availability: There are significant benefits of geothermal energy that wind and solar do not have. However, current U.S. technologies limit the use of geothermal energy to hydrothermal resources - reservoirs of steam or hot water – which are available primarily in the western states,

Alaska, and Hawaii. Recent visits to Australia and New Zealand reinforced the viability of this technology. Both countries are consistent developers of geothermal energy and continue to advance their interests in this area. Since much of the hydrothermal resources exist at very shallow depths and are relatively easy to access, their governments have been supportive of developing geothermal infrastructure and have set forth ambitious plans to expand geothermal development as part of the country's renewable energy portfolio. Other enormous and world-wide geothermal resources - hot dry rock and magma, for example - are awaiting further technology development. Geothermal is available 24 hours a day, 365 days a year and therefore is a source of baseload power. Geothermal power plants have average availabilities of 90% or higher, compared to about 75% for coal plants.[66]

Price: Costs of a geothermal plant are heavily weighted toward up front development costs rather than fuel**.** The initial cost for the field and power plant is around $2500 per installed kW in the U.S. Operating and maintenance costs range from $0.01 to $0.03 per kWh.[67]

Environment: Geothermal energy is projected to produce only about one-sixth of the carbon dioxide that a natural-gas-fueled power plant produces, and very little if any, of the nitrous oxide or sulfur-bearing gases. Certain types of geothermal plants use closed cycle operations and release essentially no emissions.

<u>Other Energy Sources</u>

Hydrogen and Fuel Cells—Tapping the Most Common Element in the Universe: Technology exists today to extract hydrogen from natural gas using steam methane reforming.[68] This technology has potential to justify a nationally distributed network of hydrogen and reduce our dependence on foreign oil. However, since natural gas is a fossil fuel, producing hydrogen from natural gas releases carbon into the atmosphere, albeit at a rate much less than oil. Unfortunately, although it is within our technical means to produce hydrogen from water, it can only be done with large amounts of electricity and as such, is not currently economically viable.[69] Since burning hydrogen as a fuel only generates water vapor as a by-product, generating hydrogen from water could be the ideal solution for the environment. However, this ideal solution is likely decades away, pending further research and development.

Hydrogen has potential to be used in fuel cells for transportation and electricity generation. Fuel cell engines, in themselves, generate no CO2 emissions. The fuel cells and the propulsion system are estimated to cost approximately $29,000, while the propulsion system for a battery electric vehicle (BEV) is approximately $20,000.[70] In addition, production costs of the hydrogen are estimated at four times the amount of an equivalent amount of electricity for a BEV.[71] Finally, the costs to build the hydrogen distribution infrastructure are estimated between $100 billion and $600 billion.[72] A BEV system would obtain its power from the existing power grid, making it far less costly. Therefore, fuel cell vehicles are not economically feasible at this time and further research and development is needed to lower costs in order to make it a viable option.

Biomass, Landfill Gas, Waste—Very Useful Waste: Biomass refers to the process of burning biologically produced materials, such as wood, leaves, agricultural leftovers, etc., to generate heat.[73] Landfill gas consists largely of methane that can be captured and used as fuel. Trash waste can also be burned as waste. EIA estimates that there is 590 million wet tons of biomass available in the US annually. Biomass is currently the largest non-hydroelectric renewable source of electricity in the United States. [74]

Source: http://newpapyrusmagazine.blogspot.com/2008/10/cost-of-non-carbon-dioxide-polluting.html	**Cost per KW**
***Current fossil fuel dominated economy*:**	
coal	**2.4**
natural gas	**6.8**
oil	**9.6**
Amongst non-carbon dioxide polluting energy technologies:	
hydroelectric	**0.85**
nuclear	**1.68**
garbage incineration (non-subsidized)	**4**
wind (non-subsidized)	**5.4**
solar thermal	**6**
home photovoltaic	**37.78**
home photovoltaic (Cloudy climate)	**83.13**
commercial photovoltaic (Sunny climate)	**27.49**
commercial photovoltaic (Cloudy climate)	**60.47**
industrial photovoltaic (Sunny climate)	**21.41**
industrial photovoltaic (Cloudy climate)	**47.11**

Table 1: Guideline electricity generation costs today (cents/kWh)[75]

II. KEY CHALLENGES AND PROPOSED SOLUTIONS

CHALLENGE #1: Transportation—At the Mercy of a Globalized Oil Economy

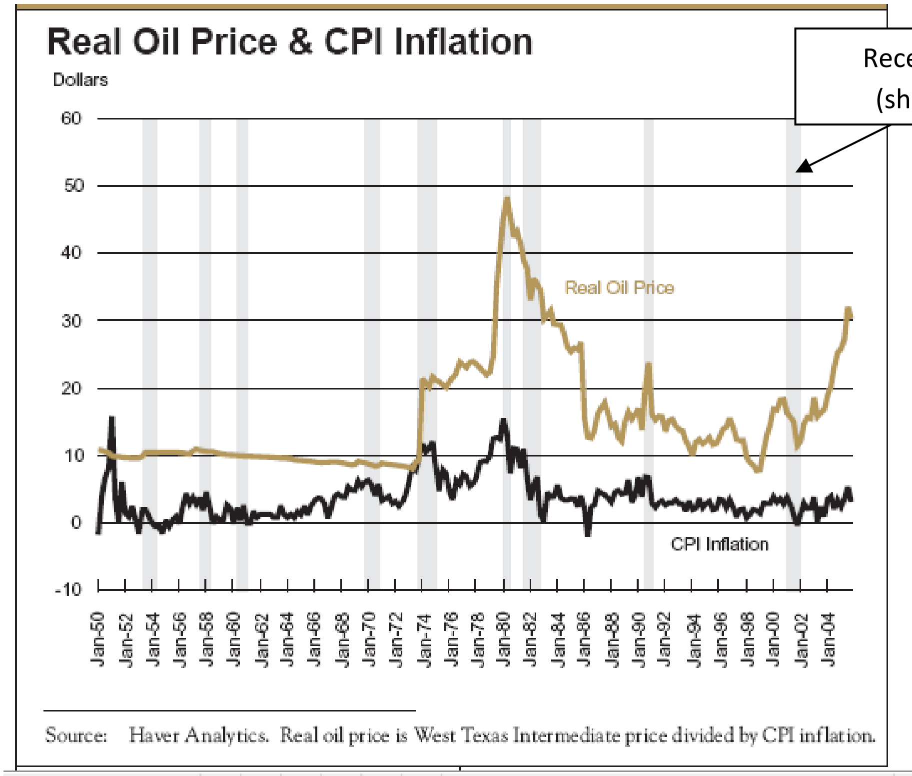
The U.S. transportation sector is 96% reliant upon a global, competitive commodity—oil. As a result of U.S. reliance on oil imports and the increased competition for this commodity, the US is vulnerable to price shocks. First, oil is traded as a commodity on the global energy market. As such, supply disruptions to the oil market, no matter where in the world, impact global prices and by default, U.S. energy prices. Second, because the U.S. imports over $2 *trillion* dollars worth of goods/services annually,[76] increases in energy prices globally affect the price of U.S. imported goods/services and as a consequence, the U.S. economy as a whole. Third, the globalized nature of the energy market requires a global production and transportation network to move energy resources from the supplier to the consumer. Table 2 (on next page) shows the major vulnerabilities or chokepoints to this global oil production/transportation network. These chokepoints "include ports, processing centers, or any other systems where disruption could potentially interrupt or even eliminate a substantial volume of the worldwide oil flow/supply."[77] These chokepoints represent between 1% (i.e., 1.2 million barrels/day) to 20% (i.e., 17 million barrels/day) of the world's daily oil demand. While a detailed study of each chokepoint is beyond the scope of this paper, these chokepoints represent a significant vulnerability to the overall energy market. For instance, 20% of the world's oil flows through the Straits of Hormuz. At its narrowest point, this strait is only 21 miles wide. During the Iran/Iraq war, oil flow through the Straits was reduced by 25%.[78] This disruption in the oil supply caused an increase in U.S. energy prices and

contributed to the recession of the early 1980s. These chokepoints, America's continued reliance on imports to meet its energy needs, the concentration of the world's oil resources in historically volatile regions and the globalized nature of the energy market, result in America's continued vulnerability to energy shocks.

	Chokepoints	% of Total World Demand	Export Destination	Location
1	Strait of Hormuz	20%	Europe, U.S., Asia	Persian Gulf
2	Strait of Malacca	18%	Asia	Indian/Pacific Ocean
3	Abqaiq Processing Facility	8%	Europe, U.S., Asia	Saudi Arabia
4	Suez Canal and Sumed Pipeline	5%	Europe, U.S.	Egypt
5	Bab el-Mandab	4%	Europe, U.S., Asia	Red Sea; Gulf of Aden
6	Bosporous/Turkish straits, Baku and CPC pipeline	3%	Europe	Turkey
7	Mina al-Ahmadi Oil Port	2%	Europe, U.S., Asia	Kuwait
8	Al Basrah oil terminal	2%	Europe, U.S., Asia	Iraq
9	LOOP	1%	U.S.	Deep Water Port, Gulf of Mexico
10	Druzhuba pipeline, Russia	1%	Europe	Russia

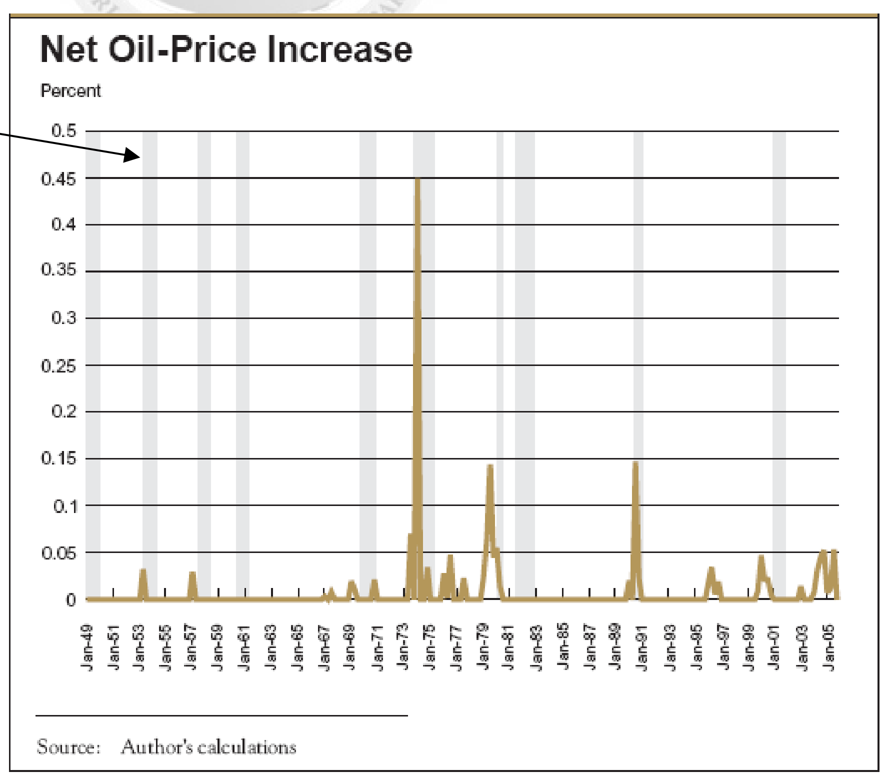
Table 2. Oil Chokepoints[79]

With the U.S. vulnerable to price shocks, it is essential to understand the adverse effects these shocks have on the economy. According to the Congressional Research Service (CRS), oil price shocks preceded nearly every U.S. recession since World War II.[80] Figure 1 illustrates the price of oil during periods of recession since 1950. Figure 2 shows the "net oil price increase" over the same period. The "net oil price increase" is the highest price of oil for a given quarter divided by the highest price over the past 12 quarters. This technique averages out price fluctuations and highlights true increases in oil prices. Again, as highlighted in Figure 2, nearly every recession (shaded in gray) is proceeded by an increase in net oil prices. In October 1973, for instance, following the Yom Kippur War, OPEC cut production by 5 million barrels a day or approximately 7% of it total production.[81] As a result, oil prices doubled and U.S. GNP fell 2.5%.[82, 83] It is important to note that it's *not* high oil prices that result in recessions, but rather the *sudden increase* in energy prices that lead to economic slow down. According to the CRS, "it is the rise in energy prices, rather than 'high' energy prices, that cause these macroeconomic problems."[84] Sudden increases in oil prices, for example, raise the cost of production. In response, producers typically cut back on production of goods causing a decrease in output and an increase in unemployment.[85] Additionally, consumers, faced with rising energy prices (without a corresponding rise in wages), typically reduce spending causing a drop in aggregate demand. Taken together, this slow down in production, increased unemployment and decreases in consumer demand typically leads to a recession.



Source: Haver Analytics. Real oil price is West Texas Intermediate price divided by CPI inflation.

Figure 1. Price of Oil over Time[86]



Source: Author's calculations

Figure 2. Net Oil Price Increases[87]

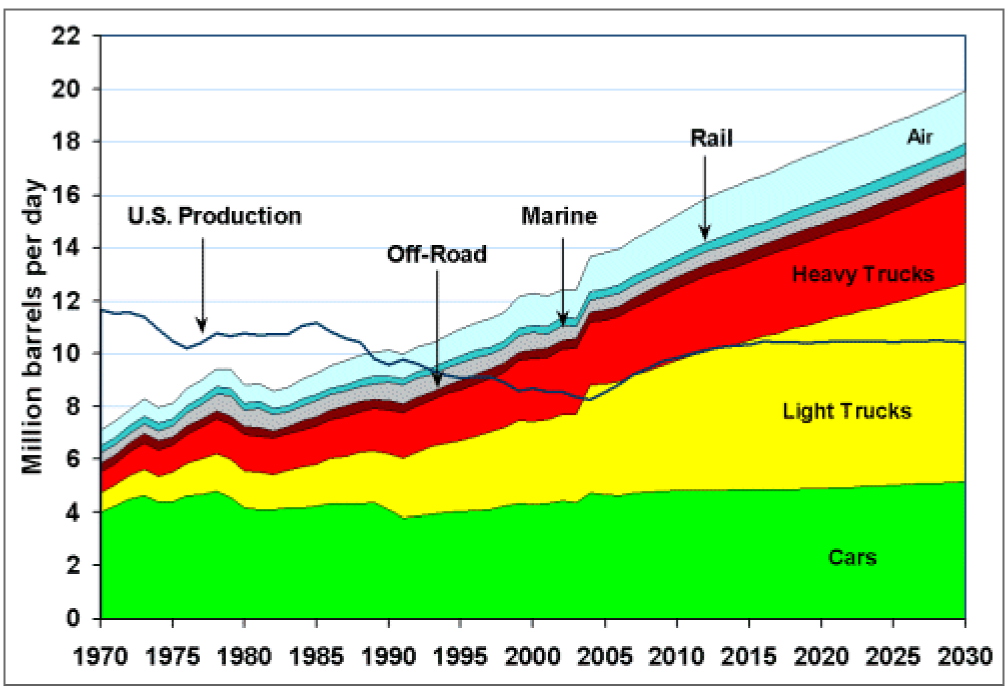
According to the International Energy Agency (IEA), a $10 per barrel increase in the price of oil would cause the loss of approximately $255 billion in world GDP in the year following the increase. While it is true the increased oil prices do provide a short term economic stimulus to oil *exporting* nations, this short-term economic stimulus is significantly outweighed by the negative effect of higher prices (i.e., increased unemployment and recession pressures) on economic activity across *importing* nations.[12] The CRS quantifies this relationship stating that the "cumulative effect of a 10% increase in oil prices during a one-quarter (3 month) period would be to reduce economic output by 0.2 to 1.1% over the next year."[88]

It is important to note the Strategic Petroleum Reserves (SPR) can be used to prevent or reduce the adverse effects of a "severe energy supply disruption" to the transportation sector.[89] The SPR can provide up to 4.3 million barrels per day for up to 90 days. After 90 days, the SPR can provide reduced amounts of oil per day for up to an additional 90 days.[90] While this reserve is helpful for an immediate, short-term oil shortage, it is of less value when the price of oil reaches high levels which are sustained for months or years.

PROPOSED SOLUTION #1: Increase Conservation through Transportation Paradigm Shift

America has the means today to dramatically reduce its dependence on foreign oil and susceptibility to price shocks through reduced consumption. With current technology, plug-in hybrid vehicles are capable of attaining over 50 mpg (Toyota Prius), while diesel plug-in hybrids are being tested at 70 mpg.[91] However, the current Corporate Average Fuel Economy (CAFÉ) standards woefully lag. The standard for 2011 is only 27 mpg, even though the average new car sold in 2008 was rated at 28.5 mpg.[92] Even the most recent standards mandated by the Energy Independence and Security Act of 2007 only increase this standard to 35 mpg by 2020. By 2020, with further development of technology, it could easily be 70 mpg. Leveraging these types of technologies is the easiest way to dramatically reduce U.S. dependence on foreign oil. As figure 3 illustrates, the greatest reduction in transportation-related oil-based fuel consumption can be gained by focus on cars and light trucks as the initial target group.

Figure 3: Fuel Consumption by Vehicle type



First, as proposed by the current administration, CAFE standards need to push for higher fleet-wide efficiencies at an almost exponential rate versus a slow ramp up. Congress allowed automakers a decade, 1975-1985, to roughly double the fuel efficiencies of their fleets. However, after meeting that goal and without pressure from Congress, automakers had little motivation to pursue increases beyond the mandated goals. Today, some scientists[93] believe "automakers already have the technology to make cars with better fuel economy. But for the past 20 years, they have used these tools to double power and increase vehicle weight by 25 percent."[94] While the benefits of increased CAFÉ standards would reduce consumption, these benefits are not without their downsides. The downsides include increased costs of new vehicles engineered to meet these higher standards and potential for increased collision-related injuries due to smaller, more light-weight vehicles. With that said, the economic, environmental, and national security benefits of reducing U.S. dependence of foreign oil outweigh (but don't diminish) the increased costs and risks associated with pursuing increased CAFÉ standards.

Second, a new gasoline/diesel tax, while politically unpopular, is an effective method to "encourage" energy conservation and reduce U.S. dependence on foreign oil. Currently the U.S. adds an 18 cents/gal road tax on gasoline. An additional gasoline/diesel tax should be set at a level to make substitutions more economically viable, possibly ~ $1/gal. For instance, the higher cost of gas will encourage investment in alternative fuel vehicles such as during the high gas prices in 2008. Consumers, for their part, would purchase/use alternative fuel vehicles based on these predictably high energy prices. This increased use of alternative fuel vehicles would reduce overall energy consumption and as a consequence, reduce U.S. vulnerabilities to oil-based price shocks. This new gasoline/diesel tax has an additional benefit of reducing carbon emissions.

Clearly, this new gasoline/diesel tax has some drawbacks. First, it should be phased-in in a way which would prevent an economic contraction that can accompany tax increases. For instance, some have argued that a larger gasoline/diesel tax would in fact lead to an economic contraction in the same way a price shock leads to a recession. However, as discussed above, it's the *sudden increase* in energy prices, not high energy prices that cause economies to contract. By phasing in the preplanned gas tax incrementally, one could give the economy time to adjust to these incrementally higher energy prices without driving the economy into a deep recession. Second, since this gasoline/diesel tax is a regressive tax, the revenue gained needs to be used to offset the impact of this tax on lower income families (possibly through some sort of voucher system) and to fund research and development on alternative energy sources/associated infrastructure.

CHALLENGE #2: Aging and Inefficient Electricity Generation/Transmission/Distribution

The current electrical grid is "aging and stressed [and] is no longer adequate to meet the demands of the 21st century."[95] There are nearly 5,000 power generation plants with a capacity to produce approximately 986,000 MWh[96] that transmit across 204,000 miles of transmission lines in North America (157,810 miles in the U.S.).[97] Over the next ten years, electricity demand is expected to grow by more than 200,000 MWh of new capacity, however electric transmission capacity is only expected to grow by 4%. This could lead to congestion and reliability issues.[98]

The bulk power system in North America is comprised of the major interconnected power grids: the Eastern, the Western, the Texas Interconnected Systems, and the Quebec Province power grid. The Eastern and Western Interconnected systems have limited connections with each other and the capacity of those connections is far less than the capacity of the transmission lines within

the Interconnects.[99] The East and West Grids are completely integrated with the Canadian grid. The Texas Interconnected System has almost no connection with the Eastern and Western Systems, but along with the Western System it is linked with Mexico.

The Consumer Energy Council America noted that investment in the transmission grid was at a low of $83 million per year from 1975 to 1999. It increased to $286 million annually from 1999 through 2003. Although the investment increases are good, total U.S. transmission capacity decreased by approximately 19% per year between 1992 and 2002. Investment in transmission lines during the next 10 years is expected to be $3 billion to $4 billion per year, while the line-miles of transmission added will be only one third the rate of electricity demand. In addition, transmission maintenance expenditures have decreased at a rate of one percent annually since 1992, which can affect the reliability of the system.[100] Furthermore, over the past 10 years, utilities have been reluctant to put major investment into transmission lines without knowing how deregulation would affect these assets; therefore, the growth of the grid was slow and remains so."[101]

The average age of transformers in service is 40 years, and for circuit breakers is 60 years.[102] Additionally, the lack of sufficient cross integration links between the Eastern and Western Interconnects results in electricity "looping" or needing to flow between the Eastern and Western Interconnects by moving "up" through the Canadian Interconnects and then back "down" to either interconnect. This leads to line loss (~7% during transmission)[103], possible service disruption and increased costs.[104] The result is heavier use on older equipment, increased congestion, increased power disturbances and outages with longer down times, lower reliability and increased costs for consumers[105].

Estimates to rebuild above the ground transmission lines is $1-2 million a mile, assuming utilities can overcome the challenges associated with permissions to build.[106] Typically, conversion of above ground transmission lines to underground is $10 million per mile.[107] This could result in large increases to customers' electric rates.[108] Operating and maintenance costs for buried transmission lines are less than overhead lines (up to 90 percent cheaper), however the repair of individual faults to underground lines can be much higher, particularly when the additional time required to repair faults is taken into account.[109] Buried transmission lines also tend to have a 50% shorter life cycle[110] as compared to overhead lines, making the replacement costs more expensive too. The cost of these repairs represents a huge challenge to the transmission industry.

Not only does the current grid have challenges with the transmission side but there are also challenges with the distribution side. The aging infrastructure results in outages and fluctuations in voltage and frequency that falls short of the consumers demand for reliable electricity to power information technologies, appliances, and other items that use computer chips to properly operate the device.[111]

Additionally, shifting the transportation paradigm as previously discussed could place even more pressure on the transmission grid. For instance, charging an electric car can be the equivalent of running up to six plasma television sets at once — a big energy drain. As a result, electric cars and plug-in hybrids pose a challenge for utilities caught unprepared for a high concentration of electric vehicles within their markets by overwhelming the grid.[112]

PROPOSED SOLUTION #2: Upgrade & Improve Electricity Transmission/Distribution

A better performing grid would result in reduced fuel consumption and less greenhouse gas emissions. Termed the "smart grid" or "intelligent grid," this system is based on smart sensors and

meters on private residences and commercial facilities that enable two-way communication and even control of devices (i.e. refrigerators and air conditioners) to deliver electricity more efficiently across the transmission/distribution system.[113] The smart grid concepts enable utilities to better use their equipment and manage the load by automatically reconfiguring the network to relieve congestion. In short, with thousands of sensors, system operators will have a better understanding of how the entire system is working and can be predictive vice reactive to grid management and emergencies.[114] The two-way communication can identify peak loads to the utility and inform the consumer of pricing changes during peak loads. In turn, consumers can make choices to use electricity more wisely, saving energy/costs, and enabling utilities to flatten peak loads across the system. This could reduce demand and limit the need for less environmentally friendly power generation plants to come on line in order to meet the peak demand.[115]

To ensure nation-wide interoperability and connectivity of the smart grid, the Federal Energy Regulatory Commission (FERC), in coordination with industry, must develop a national standard and implement a plan to establish the smart grid. FERC needs to establish a standard time for States to rule on siting requests, with a built in approval/appeal process to allow FERC to elevate discussion to a federal level when State decisions adversely effect the public's greater good.

Converting to a smart grid requires a significant investment--a conservative estimate is $375 million for every 1 million customers with a project completion time of up to 10 years.[116] In addition to the cost, there is a downside to the smart grid, namely ensuring cyber security. Because these systems will connect the entire electric system to an unprecedented level, the risk and vulnerability of the electric grid increases. "Among other concerns, the computer systems used to remotely control process equipment were highlighted as specific points of vulnerability."[117]

While there is increased vulnerability, the risk is relatively low because it will use closed networks to communicate. To mitigate this risk, the system must be implemented with Cyber Security principles and technologies to protect the control systems from remote access through internet connections that link consumers and generators through the transmission/distribution grid. Information assurance standards and procedures for protecting these systems must be developed and matured to combat the ever-changing attack.

CHALLENGE #3: Reverse Growth of Residential/Commercial Energy Consumption

Energy use per capita in America (337 million BTUs per person in 2007) has remained steady since the early 70's. There are more than 112.3 million[118] more Americans consuming their "per capita" of America's available energy today than there were in 1970. Near term, the per capita share trend is not likely to decline. Estimates indicate that over the next 20 years, U.S. demand for electricity will rise by 45 percent.[119] Curbing this growth will require changes in both the workplace and the home.

The growth in residential energy consumption is also being driven by the growth in America's demand for electronic appliances. This includes the common TV. The number of TVs in use at the end of 2008 topped 300 million, and today's 42-inch plasma TVs can consume more electricity than a full-size refrigerator, dethroning it as the highest energy consuming appliance in the home.[120] However, to avert the increasing risk over-consumption places on America's base-load generation capacity, a strategic communication plan (discussed later) will be needed to educate the average consumer of their role in this strategic-level effort. Although most green technology currently comes at a higher cost, there are numerous things and behaviors that if

incorporated into the average home would generate additional energy savings, like using compact fluorescent lights or how to effectively use blinds or window shades to maximize passive heating during the winter or prevent it during the summer.

PROPOSED SOLUTION #3: Institute CAFÉ-like Standards for Residential/Commercial Buildings

Recent studies, by the New Buildings Institute and the CoStar Group, have shown that third party certified commercial buildings (i.e. agencies using ENERGY STAR or LEED certification criteria) outperform their conventional counterparts across a wide variety of metrics, including energy savings."[121] By pursuing ENERGY STAR or a LEED certification, company leaders and their employees become more educated about energy and take more calculated efforts to reduce energy consumption. The results are impressive. Depending on the level of LEED rating, certified buildings spend 25-50% less on energy. ENERGY STAR rated buildings are realizing a 40 percent savings. Unfortunately, there is a national level void for similar programs for residential homes. Creating standards for homes would result in huge benefits.

Creation of national standards to decrease residential energy consumption would have tangible savings, much like CAFÉ standards achieved for the auto industry. With America rapidly transitioning to digital TV and increasing its demands for plug-in electric vehicles, the demands on existing base-load generation capabilities could be staggering. By the time the plug-in electric vehicles start permeating a significant number of American homes, the transition to digital TVs will be nearing completion. However, the need for a CAFÉ-like standard for new homes will become even more crucial since "plugging in an electric car can be the equivalent of running up to six plasma television sets at once — a big energy drain…Electric cars and plug-in hybrids could pose a challenge for utilities that aren't ready for them" since a concentration of cars in a relatively small area could overwhelm the grid.[122]

CHALLENGE #4: Balancing Environmental Risk with National Energy Needs

The use of fossil fuels may be harming our planet in terms of carbon dioxide emissions and global warming. The science behind the link between greenhouse gases/climate change is fairly well documented. Several types of "greenhouse" gases trap heat in the atmosphere including water vapor, carbon dioxide, methane, chloro-fluoro carbons gases and ozone. Of these, carbon dioxide is the most abundant and makes up 60 percent of the greenhouse gases in the atmosphere. The quantity of greenhouse gases, particularly carbon dioxide, in the atmosphere has increased by 31 percent since pre-industrial times.[123] Most attribute the rise in carbon dioxide to the burning of fossil fuels, deforestation, and other activities.

This increase in greenhouse gases is contributing to increased temperatures. The world's leading scientific authority on global warming, the Intergovernmental Panel on Climate Change (IPCC), states the "warming of the climate system is unequivocal."[124] Prior to the industrial revolution period, carbon dioxide levels in the atmosphere remained below 300 parts per million. Since this period, carbon dioxide concentrations have steadily increased to a level of 380 parts per million today and continue to rise at a rate of 2 parts per million each year.[125] At the same time, from 1906 to 2005, the temperature has increased 0.74 degrees Celsius (1.30 degrees Fahrenheit).[126] Of particular concern, the IPCC found that of the 12 warmest years on record, 11 have occurred since 1995. In addition, global sea level rose at an average rate of 1.8 millimeters per year from 1961 to 1993, but at a rate of 3.1 millimeters per year since.

This climate change can threaten regional stability as food, water and other resources become scarce in the developing world. According to the IPCC, continued greenhouse gas emissions at or above the current rates would cause further warming with global impacts very likely greater than those already observed during the 20th century.[127] Because of this, most scientists agree that "we" should stabilize total greenhouse gas concentrations at a level that is slightly higher than today's level in order to avoid the worst effects of climate change. Furthermore, there is a growing consensus that we must maintain carbon dioxide levels lower than 450 parts per million. According to the IPCC, stabilization of carbon dioxide concentration levels of 400 to 440 parts per million could limit the cumulative rise in global temperature to 2.4 to 2.8 degrees Celsius (4.3 to 5.0 degrees Fahrenheit).[128]

PROPOSED SOLUTION #4: Reduce Carbon Emissions

Significant reductions in the carbon footprint of our energy sources can be effective at stabilizing carbon dioxide levels and thus limiting the adverse effects of climate change. As the largest producer of greenhouse gases, the U.S. needs to take a leadership role in this area with the long term vision of becoming global leaders in the affordable, carbon friendly energy industry. Recent visits to both New Zealand and Australia confirm that other OECD nations are looking toward the U.S. to provide leadership in developing the carbon friendly energy sources.

Currently, nuclear and hydroelectric power are the only non-carbon power generation sources that produce significant amounts of energy. Significant investments are needed to spur the innovations needed for the other renewable, carbon friendly energy sources to scale to the size required to reduce coal and natural gas power generation. Additionally, barriers should be removed and regulation processes should be streamlined in order to allow currently feasible clean energy sources to expand. The U.S. must also work to decarbonize current energy sources by capturing and storing carbon. Much work is being done to capture and store carbon from coal, but these technologies have not been deployed on a wide-scale and have several long-term storage challenges. Continued investment and research is required for the United States to leverage its coal resource strengths and to demonstrate environmentally sound "do as we do" policies.

In addition to increased investments and reduced barriers/regulations, the U.S. must design and implement a system of economic incentives (or disincentives) to reduce carbon emissions. A system based on a carbon tax should be utilized. Unlike a cap and trade system, the carbon tax system provides businesses with known costs for carbon emissions, is transparent and is fair/equitable. For example, the carbon tax reduces the likelihood of political favoritism regarding the allocation of carbon credits and would be applied consistently/equitably across the U.S. This avoids the transfer of wealth from the heavy carbon emitters in the mid-West to the power generation companies in the East.

While the U.S. should take a leadership role in addressing environmental concerns, the U.S. alone cannot reduce greenhouse gases to the levels necessary to mitigate global climate change. For instance, the U.S. and China produce 40 percent of global greenhouse gas emissions. As such, an enhanced partnership between the U.S. and China is needed to address this global issue. Any international agreement must first find accommodation for both the U.S. and China as a critical first step forward.

Reducing carbon emission does have its drawbacks such as increased cost. The exact economic costs are hard to predict since carbon capture, sequester technologies, and affordable alternatives are still in their infancy.

III. PROPOSED NATIONAL ENERGY STRATEGY

An effective national energy strategy must include 1) designation of a clear, responsible commission for leading long term national energy security planning/implementation, 2) diversification of America's energy portfolio, 3) assumption of a global leadership role in the energy area, 4) prioritizing/incentivizing innovations, and 5) reducing energy consumption. This comprehensive, long-term strategy must transcend the changes in presidential and congressional leadership and the tendency to make short-term changes in policies and priorities which are inconsistent with these long term goals. This will reduce uncertainty, generate confidence, and trigger more investment and innovation within the private sector. As an example, currently within the government, "responsibility and oversight for energy development and use rests with at least 13 federal agencies and independent regulatory commissions and numerous committees in both the House and the Senate."[129] The lack of central leadership is an impediment to implementation of an effective energy strategy.

National Energy Leadership—Appointing a Lead: Consistent, apolitical leadership is needed to address the long term energy concerns facing the U.S. As our executive and legislative branches largely suspend partisan and constituent interests to meet critical national security concerns, our nation's leaders must also come together and be willing to do the same to meet our nation's long-term energy needs. Doing so requires strong leadership and sacrifice from our elected officials. There is no single leader or agency designated to resolve long-term interagency strategies regarding energy policy or to ensure a consistent, comprehensive commitment to energy security. One approach would be to have the Administration and Congress support the designation of a keeper of the energy vision flame. This would be similar to how the national security flame is held by the National Security Council and is radiated out through the Departments of State, Defense, and Homeland Security. To be effective, the designated entity must be autonomous, apolitical, and have both energy revenue redistribution and policy setting authority. This autonomous approach would ensure long-term consistency towards energy strategy implementation and enhance U.S. global leadership in potentially volatile energy crisis.

Once designated, the lead agency must develop a strategic communication plan. If national energy leadership 1) clearly communicate a viable strategy connected to desired end states, 2) offer specific actions Americans can take, and 3) demonstrates that these actions benefit the nation, Americans will support it. It is crucial to set forth quantifiable national goals which incentivize the best and most efficient use of resources, one example being the use of technologies that are readily available today or charting a path for making them available in the near future. The plan to raise Americans' awareness that an energy challenge exists may prove to be the single most important step of the strategy. A very successful example of increasing awareness on a national scale can be taken from the stop littering campaigns in the 1970s in the U.S. Commercials such as the American Indian depicted shedding tears as America dumped garbage had a major impact. A similar strategy would be very effective to increase public awareness of energy use and misuse.

Diversification—Not Placing All Eggs in One Basket: Shifting from an oil/carbon-based economy by increasing availability to more environmentally responsible energy alternatives is critical to 1) mitigating international tensions, 2) reducing vulnerabilities to oil price shocks, 3) decreasing carbon emissions and 4) providing long term energy security. A consistent long term strategy towards diversification is critical to ensuring the long term growth of the U.S. economy. Nuclear energy technology is proven and the U.S. should increase its role in the U.S. energy market. At a minimum, the nuclear energy should maintain its contribution to total electric power

generation as consumption increases, or preferably expand. Also, spent nuclear fuel reprocessing should be allowed to reduce the amount of waste. Wind and solar are also technically viable, proven forms of power generation and should constitute a larger portion of America's energy portfolio. While it appears to be environmentally untenable to expand hydroelectric power generation, current capacity should be maintained and modernized to enhance efficiency. Although other renewable sources are showing promise, they will need greater development before they can significantly contribute to the U.S. energy market.

U.S. Global Leadership—Out Front in an American Way. While shifting from an oil/carbon-based economy is critical to 1) mitigating international tensions, 2) reducing U.S. vulnerability to price shocks, 3) decreasing carbon emissions, and 4) providing long term energy security for the U.S., another issue must be addressed. To fully realize the benefits from this shift towards a more diversified energy portfolio, the U.S. must assume a leadership role and demonstrate a commitment to propagating the benefits of known energy efficiencies and alternative/renewable energy solutions for countries around the world. As noted above, because of the global problem of carbon emissions, reversing the growth of carbon emissions cannot be solved by just one country. Because of the global nature of the energy market, reducing U.S. demand for fossil fuels will not eliminate the international tensions tied to the competition for these scarce energy resources, nor eliminate the affect of volatile energy prices on the global (and by default, the U.S.) economy. In fact, many countries around the world face energy challenges similar to the challenges the U.S. currently faces. For example, as noted during May 09 visits to Australia, the Australian's noted they export significant amounts of coal to China, the largest consumer of coal in the world. Like the U.S, all three countries generate the majority of its electricity from coal. Australia energy experts mentioned their energy industry is looking towards the U.S. to develop clean coal or other technologies. They advocated the U.S. should assume a leadership role in the development, implementation, and deployment of clean coal/alternative fuel technology globally.

As a global energy leader, the U.S. can help shape a composite energy strategy that helps nations around the world address these similar challenges. The U.S. should not only act as conduit for sharing U.S. energy innovations worldwide, but more importantly, the U.S. must serve as a facilitator. This means bringing nations together and enabling them to use the best energy innovations available around the globe. This will help fulfill the aspirations of all people around the world for economic growth, abundant and affordable energy, an improved quality of life, and a clean environment.[130] Some noteworthy examples worth investigation and sharing include:

- India's program to promote graduate programs in energy efficiency and conservation that could accelerate innovations across the energy market.
- Japan's "Law Concerning the Rational Use of Energy (Energy Conservation Law)" that outlines specific actions for energy users and the government agency that is responsible for compliance with this law.
- New Zealand's geothermal technology
- France's success with the La Rance tidal power plant

[Note: Other examples are listed in Attachment 1]

Energy Innovation—Creative Energy. Energy innovation needs to become a national priority**.** The U.S. has a robust heritage of invention and innovation which has enabled its success as a global leader by providing the means for the U.S. to develop strong political, economic and military tools. Energy development through technological innovation and encouraging

conservation is paramount. The government should focus on innovation necessary to improve storage capacity, transportation of energy sources, and modernizing the energy infrastructure as these actions will contribute toward conservation and reduced energy costs in the long-run. The initiatives should include promoting the development of new energy sources, moving in the direction of burning coal more cleanly, and transforming the U.S. transportation sector.[131] The U.S. is spending a total of $4B on clean energy R&D, compared to approximately $700B spent on oil imports in 2008.[132] This clearly indicates that clean energy R&D is a not priority. The U.S. must invest more in clean energy R&D—there needs to be an increase in funding to stimulate technical innovation necessary to advance to a more secure energy posture.

The U.S. as part of public/private partnerships should invest in advancing clean technologies and renewable energy sources. Rapid development and deployment of technologies to balance the energy portfolio will work to sustain America's economic comparative and competitive advantage as well as address environmental concerns. The use of renewable portfolio standards have shown to be effective in generating growth in this area. Another recommended approach is the use of feed-in tariffs — also known as "standard offer contracts" — which guarantee long-term preferential rates to small renewable energy developers so they can compete on price with conventional (and less costly) forms of power.

Consumption Reduction—Use Less to Need Less. In order to maximize effectiveness of this national energy strategy, reductions in consumption must accompany diversification and energy innovation efforts. Otherwise gains will be quickly offset by growth in consumption. Effective reduction of energy consumption should be accomplished through the strategic communication plan, and a series of nationwide standards and initiatives such as "smart metering," carbon tax, and gasoline/diesel tax.

V. CONCLUSION

When determined, the U.S. can literally "fly to the moon." As the U.S. has done with the space program or other national challenges, it is time to take this same dedication into our national energy and related environmental realms. Energy is the foundation of America's economic well being, national security, and quality of life. Much of America's national power is built on a foundation of inexpensive, readily available, and reliable energy. Any U.S. failure to adequately address global challenges will weaken American political influence, military power, and economic strength. Unfortunately, the current energy challenges facing the U.S. are very complex and there is no silver bullet answer. As much as the U.S. needs to focus on its own energy needs, it must also have 1) global energy awareness, 2) a real concern about the energy requirements of other nations, and 3) demonstrate a consistent "do as we do" leadership role. Energy is a global issue, not simply a domestic one.

The next step for the U.S. is clear--***we must develop a cogent, comprehensive national energy strategy within a global context or face problems in the future***. Global interdependence will continue to magnify the impacts of energy related issues. To mitigate the intensity of these issues, America needs a responsible energy agency that understands the national energy portfolio, can address the most profound U.S. challenges to include the continued reliance of foreign oil in the transportation sector, aging/inefficient electricity generation/transmission infrastructure, increasing energy consumption, and growing environmental concerns, and, most importantly, take specific actions to fulfill a long term vision for energy. The cornerstone for this long term vision is a national energy strategy that includes *five key elements*:

- **Designation of a clear, responsible commission for leading long term national energy security planning/implementation,**
- **Diversification of America's energy portfolio,**
- **Assumption of a global leadership role in the energy area,**
- **Prioritizing/incentivizing innovations, and**
- **Reducing energy consumption.**

The imperative for doing this was highlighted by President Obama stating "*we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity*."

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